

(NASA-CR-198952) GUARANTEED TIME
OBSERVATIONS SUPPORT FOR FAINT
OBJECT SPECTROGRAPH (FOS) ON HST
Technical Progress Report, 1 Nov.
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Technical Progress Report**Guaranteed Time Observations Support
for Faint Object Spectrograph (FOS) on HST****NAG5-1630****November 1, 1994 -- April 30, 1995****Richard Harms, P.I.****University of California, San Diego
9500 Gilman Drive, La Jolla CA 92093-0111****I. Overall Progress****A. Results Obtained During the Reporting Period****1. GTO Observations**

The goals of the GTO effort are for investigations defined in previous years by the IDT to be carried out as HST observations and for the results to be communicated to the scientific community and to the public. The following is a listing of FOS GTO observations in the report period, as far as we can tell in the absence of daily OSS reports.

Date	SMS	Prop	Cycl	Orig#	PI	Title	Target
(FOS "PI": Angel, Bohlin, bUrbidge, Davidsen, Ford, Harms, Margon)							
Scheduled, and known to have been completed							
10/16/94	94.289	5128	4	1045	D	Search for Primeval Galaxies (FOS 25)	U DHM0054-284
11/27/94	94.325	5682	4	1026	U	UV Spectra of Low-z QSOs (1), Aug	PG 0026+12
12/12/94	94.346	5124	4	1036	F	Imaging & Spectr Seyfert Nuclei (FOS 14)	R,B NGC4261
1/5/95	95.002	5095	4	1028	U	Spectra <3000A for QSOs z~2.0 (3), Cy 4	PKS 1148-001
1/26/95	95.023	5683	4	1030	U	Gravitationally Lensed QSOs, Aug	R PKS 0957+561
2/22/95	95.051	5744	4	1044	F	Stellar & Gas Dyn Normal Galax (24), Aug	M31 (NGC224)
4/9/95	95.093	5095	4	1028	U	Spectra <3000A for QSOs z~2.0 (3), Cy 4	B21224+317
1/22/95	95.016	5124	4	1036	F	Imaging & Spectr Seyfert Nuclei (FOS 14)	U NGC4151
1/16/95	95.016	5754	4	1036	F	Imaging & Spectr Seyfert Nuclei (FOS 14)	U NGC1068
5/4/95	95.121	5125	4	1040	F	Vel. Disper. in the Nuclei of Giant Ellipticals	M87=NGC4486
1/24/95	95.023	5123	4	1038	F	Imag & Spectr Nucl Act. in Liners (15), Cy4	U NGC5194
3/16/95	95.072	5123	4	1038	F	Imag & Spectr Nucl Act. in Liners (15), Cy4	U NGC4258

Scheduled, but status unknown

95.002	5666	4	1054	M	Opt Counterparts	Radio Pulsars (38) Aug Cy 3	Crab Pulsar
95.030	5128	4	1045	D	Search for Primeval Galaxies (FOS 25)		

Scheduled, but lost or failed due to various reasons (generally performed later)

safed	94.332	5683	4	1030	U	Gravitationally Lensed QSOs, Aug	R PKS 0957 [Overlight]
TA fail?	94.297	5095	4	1028	U	Spectra <3000A for QSOs z~2.0 (3), Cy 4	PKS 0109+176
bad cnfg	94.332	5089	4	1029	A	Spectropolarimetry of QSOs, Blz, AGN, Aug	PKS 2155-304

This last observation basically failed to detect the host galaxy of the bright BL Lac Object PKS2155-304. We determined that using the occulting bar only diminished the AGN light by about a factor of 10. Resulting spectrum was still the featureless continuum of the BL Lac object. Cycle 5 observations were to include occulting bar

observations of two more BL Lacs. Given the results of this Cycle 4 observation, we feel that it is highly unlikely to detect extended emission from these BL Lacs using the occulting bar and FOS and we have changed our Cycle 5 program accordingly.

Corrections or additions to previous report:

None.

2. Publications (including partial support)

a) Papers Published or In Press

- Bianchi, L., Ford, H., Bohlin, R., Paresce, F. de Marchi, G. 1995: "HST-WFPC imaging of the halo Planetary Nebula K648" A.A., in press
- Bianchi, L., Lamers, H., Hutchings, J., Massey, P., Kudritzki, R., Herrero, A., Lennon, D., 1994: "Ultraviolet and optical spectroscopy of a B supergiant star in M31" *Astron. Astrophys.*, **292**, 213
- Burbidge, E. M., 1995 "Spectra of Two Quasars Possible Ejected from NGC 4258" *A&A Letters*, accepted for publication.
- Bohlin, R. C., Colina, L. and Finley, D. 1995, "White Dwarf Standard Stars: G191-B2B, GD71, Gd153, HZ43", *AJ*, in press.
- Clayton, G.C., Wolff, M.J., Allen, R.G., and Lupie, O.L. 1995, "Ultraviolet Interstellar Linear Polarization. II. The Wavelength Dependence", *ApJ*, in press.
- Colina, L. and Bohlin, R. C. 1994, "Absolute Flux Calibration of Optical Spectrophotometric Standard Stars", *AJ*, **108**, 1931.
- Courvoisier, T.J.-L., Blecha, A., Bouchet, P., Bratschi, P., Carini, M.T., Donahue, M., Edelson, R., Feigelson, E.D., Filippenko, A.V., Glass, I.S., Heidt, J., Kollgaard, R.I., Matheson, T., Miller, H.R., Noble, J.C., Sekiguchi, K., Smith, P.S., Urry, C.M., and Wagner, S.J. 1995, "Multiwavelength Monitoring of the BL Lacertae Object PKS 2155-304. III. Ground-Based Observations in 1991 November", *ApJ*, **438**, 108.
- Edelson, R., Krolick, J., Madejski, G., Maraschi, L., Pike, G., Urry, C.M., Brinkmann, W., Courvoisier, T.J.-L., Ellithorpe, J., Horne, K., Treves, A., Wagner, S., Wamsteker, W., Warwick, R., Aller, H.D., Aller, M.F., Ashley, M., Blecha, A., Bouchet, P., Bratschi, P., Bregman, J.N., Carini, M., Celotti, A., Donahue, M., Feigelson, E., Filippenko, A.V., Fink, H., George, I., Glass, I., Heidt, J., Hewitt, J., Hughes, P., Kollgaard, R., Kondo, Y., Koratkar, A., Leighly, K., Marscher, A., Martin, P.G., Matheson, T., Miller, H.R., Noble, J.C., O'Brien, P., Pian, E., Reichert, G., Saken, J.M., Shull, J.M., Sitko, M., Smith, P.S., Sun, W.-H., and Tagliaferri, G. 1995, "Multiwavelength Monitoring of the BL Lacertae Object PKS 2155-304. IV. Multiwavelength Analysis", *ApJ*, **438**, 120.
- Hamann, F., Barlow, T.A., Beaver, E. A., Burbidge, E.M., Cohen, R. D., Junkkarinen, V. and Lyons, R. 1995 "Ne VIII $\lambda 774$ and Time Variable Associated Absorption in the QSO UM 675" *Ap. J.* **443**, 606.
- Haser, S., Lennon, D., Kudritzki, R., Puls, J., Paudrach, A., Bianchi, L., and Hutchings, J., 1995: "The stellar wind of an O8.5I(f) star in M31 - a determination of mass loss" *Astron. Astrophys.*, in press
- Martin, P.G., Somerville, W.B., McNally, D., Whittet, D.C.B., Allen, R.G., Walsh, J.R., and Wolff, M.J. 1994, "Polarization of the 2175 Angstrom Feature", in *The Diffuse Interstellar Bands*, A.G.G.M. Tielens and T.P. Snow (eds.), Kluwer Academic Publishers.
- Schmidt, G.D. and Smith, P.S. 1995, "A Search for Magnetic Fields Among DA White Dwarfs", *ApJ*, in press.

Schmidt, G.D., Smith, P.S., Harvey, D.A., and Grauer, A.D. 1995, "The Pre-Cataclysmic Variable GD 245", AJ, in press.

Smith, P.S., Schmidt, G.D., Allen, R.G., and Angel, J.R.P. 1995, "The Polarization and Ultraviolet Spectrum of Markarian 231", ApJ, **444**, 146.

Zheng, W., Kriss, G.A., Davidsen, A.F., Lee, G., Code, A.D., Bjorkman, K.S., Smith, P.S., Weistrop, D., Malkan, M.A., Baganoff, F.K., and Peterson, B.M. 1995, "Astro-1 and Ground-Based Observations of Markarian 335: Evidence for an Accretion Disk", ApJ, in press.

b) Papers Submitted

Cohen, R. D., Beaver, E. A., Diplas, A., Junkkarinen, V. T., Barlow, T.A. and Lyons, R.W., "A 21cm Absorber Identified with a Spiral Galaxy--HST/FOS and WFPC 2 Observations of 3CR 196", 1995 [submitted].

Dopita, M. A., Vassiliadis, E., Meatheringham, S. J., Bohlin, R. C., Ford, H. C., Harrington, J. P., Wood, P. R., Stecher, T. P., and Maran, S. P. 1996, "HST Observations of Planetary Nebulae in the Magellanic Clouds IV: [O III] Images and Evolutionary Ages," ApJ, submitted 95May.

Green, P.J., Schartel, N., Anderson, S.F., Hewett, P.C., Foltz, C.B., Fink, H., Brinkmann, W., Truemper, J., and Margon, B. 1995, "The Soft X-ray Properties of a Large Optical QSO Sample: ROSAT Observations of the Large Bright Quasar Survey", ApJ, [submitted].

Hamann, F., Shields, J.C., Ferland, G.J., and Diplas, A. 1995 "Probable Ne VIII $\lambda\alpha$ 774 Emission from the QSO PG 1148+549", submitted to ApJ - at referee 3/23/95.

Hamann, F., Zuo, L., and Tytler, D. 1995 "Broad Ne VIII λ 774 Emission from Quasars in the HST-FOS Snapshot Survey," in press ApJ Letters.

Hines, D.C., Schmidt, G.D., Smith, P.S., Cutri, R., and Low, F.J. 1995, "The Buried QSO in IRAS F15307+3252 and the Nature of Hyperluminous Galaxies", ApJ, submitted.

Lyons, R. W., Cohen, R. D., Junkkarinen, V. T., Burbidge, E. M., and Beaver, E. A., "The UV Spectrum of the QSO OQ 172 Observed with the Faint Object Spectrograph", AJ [1995, submitted].

Pei, Y.C., Tsvetanov, Z.I., Ford, H.C., Kriss, G.A., and Ferrarese, L. (1995), "A Black Hole in the Nucleus of M31", submitted to Ap. J

Perlman, E.S., Stocke, J.T., Schachter, J.F., Elvis, M., Ellingson, E., Urry, C.M., Impey, C.D., Smith P.S., and Kolchinsky, P. 1995, "The Einstein Slew Survey Sample of BL Lacs", ApJS, submitted.

Silber, A.D., Anderson S.F., Margon, B., and Downes, R.A. 1995, "UV Pulsations of DQ Herculis at the White-Dwarf Spin Period", submitted to ApJ.

Smith, P. S., Schmidt, G. D., Allen, R. G., and Angel, J. R. P. 1995, "The Polarization and Ultraviolet Spectrum of Markarian 231", submitted to Ap. J

Tsvetanov, Z.I., and Pertosian, A.R. (1995), "HII Region Populations in Seyfert Galaxies. I. Database", submitted to Ap. J

c) Abstracts and Invited Talks**Abstracts from the January, 1995 AAS meeting in Tucson, AZ**

- Allen, R. G., and Jordan, S., 1994 "Ultraviolet Spectropolarimetry of GRW+70 8247 with the HST Faint Object Spectrograph", *B.A.A.S.*, 26, 1383.
- Barlow, T. A. and Junkkarinen, V. T., 1994 "Keck HIRES Spectra of Three Broad Absorption-Line QSOs", *B.A.A.S.*, 26, 1339.
- Beaver, E. A., Burbidge, E. M., Cohen, R. D., Diplas, A., Junkkarinen, V. T., Lyons, R. W., and Loveland, M., 1994 "Looking for the Sources of Damped Ly α Absorption Lines in QSO Spectra", *B.A.A.S.*, 26, 1331.
- Bohlin, R., Bianchi, L., Ford, H., 1995: "HST and optical observations of the halo PN K648" *BAAS*, 26, 1385
- Cohen, R. D., Beaver, E. A., Diplas, A., Junkkarinen, V. T., and Lyons, R. W. 1994, "Observations of the 21 cm Absorber PKS 1229-021", *B.A.A.S.*, 26, 1330.
- Deutsch, E. W., Anderson, S. F., Margon, B., Downes, R. A., 1994 "HST/WFPC Imaging of Candidate Optical Counterparts for a Globular Cluster X-Ray Source in NGC 1851", *B.A.A.S.*, 26, 1488.
- Dressel, L.L., Harms, R.J., and Ford, H.C. 1994 "Kinematics of the Gaseous Disk Surrounding the Black Hole in M87", *B.A.A.S.*, 26, 1343.
- Hamann, F., Zuo, L., and Tytler, D., 1994 "Strong Ne VIII $\lambda\alpha$ 774 Emission from Quasars in the HST-FOS Snapshot Survey (Absnap)", *B.A.A.S.*, 26, 1356.
- Junkkarinen, V. T., and Barlow, T. A., 1994 "A HIRES Detection of Na I D Absorption in the Spectrum of the QSO PKS 2020-370 Due to the Galaxy Klemola 31A", *B.A.A.S.*, 26, 1330.
- Lyons, R. W., Cohen, R. D., Hamann, F. W., Junkkarinen, V. T., Beaver, E. A., and Burbidge, E. M., 1994 "UV Spectrum of the High Redshift QSO UM 670", *B.A.A.S.*, 26, 1337.
- Margon, B., Silber, A., Anderson, S. F., and Downes, R. A., 1994 "Detection of 71-s Ultraviolet Line and Continuum Pulsations in DQ Herculis", *B.A.A.S.*, 26, 1325.
- Moore, D., 1994, "Narrow-Line Region Kinematics in Seyfert Nuclei", *B.A.A.S.*, 26, 1356.
- Petro, L., Bely, P., Burrows, C., Elkin, D., MacKenty, J., Paresce, F., Storrs, A., Ranatunga, K., and Lyons, R., 1994, "Improved Dark-Sky Restrictions for HST Observations", *B.A.A.S.*, 26, 1319.
- Schmidt, G.D., Smith, P.S., Harvey, D., and Grauer, A.D. 1994, "A Pre-Cataclysmic Variable", *B.A.A.S.*, 26, 1344.
- Smith, P. S., Allen, R. G., and Schmidt, G. D. 1994, "Ultraviolet Spectropolarimetry of AGNs with the Faint Object Spectrograph: MRK 486 and 1Zw1", *B.A.A.S.*, 26, 1500.

d) Functional Work

- Evans, I. N., Koratkar, A. P., Taylor, C. J., and Keyes, C. D. (1994) FOS Instrument Science Report CAL/FOS-121 "SMOV Report IV: The Absolute Locations of the FOS 1.0 Apertures "
- Vassiliadis, E., Bohlin, R. C, Koratkar, A. P., and Evans, I. N. (1994) FOS Instrument Science Report CAL/FOS-122 "FOS Pre-COSTAR Blue Side: Target Acquisition Accuracy "
- Koratkar, A. P., Wheeler, T., Evans, I. N., Lupie, O., Taylor, C. J., Keyes, C. D. and Kinney, A. L. (1994) FOS Instrument Science Report CAL/FOS-123 "SMOV Report V: FOS Plate Scale and Orientation"
- Lindler, D. J. and Bohlin, R. C. (1994) FOS Instrument Science Report CAL/FOS-125 "Pre-COSTAR Photometric Calibration of the Faint Object Spectrograph"

Keyes, C. D., Koratkar, A. P., and Evans, I. N. (1995) FOS Instrument Science Report CAL/FOS-132 "FOS Target Acquisition Strategies (SHORT VERSION for Cycle 5 Phase II Reference)"

Lindler, D. J., Bohlin, R. C., and Keyes, C. D. (1995) FOS Instrument Science Report CAL/FOS-134 "Cycle 3 FOS Red Side Super-Flats"

Bohlin, R., and Colina, L. 1995, FOS Instrument Science Report CAL/FOS-136, "Post-Costar FOS Aperture Transmissions for Point Sources."

3. Presentations

Informing the public is also a part of our mission. FOS GTO team members gave public information lectures at all team locations. One Co-Investigator served as a panel member of the "Space Astronomy Update" forum and press conference every 1.5 months during this period. In the area of public information, we include the following:

Burbidge, E. M., "Are the Opportunities in Astronomy and the Working Conditions Different for Women and Men?", *Proc. Joint Discussion 9, IAU, 1994* [in press].

Burbidge, E. M., "Foreword", *Home is Where the Wind Blows*, by Sir Fred Hoyle, published by University Science Books (1994).

Cohen, R. D., "HST Results: Update" Astronomy Public Lecture Series, Reuben H. Fleet Space Theater, San Diego 4/26/95.

B. Scientific Significance of Selected GTO Results

Spectroscopic observations of the original **double quasar PKS 0957+561** were designed to study the structure of the Ly α forest clouds on small scales. Ground-based observations of Ly α forest absorption lines in pairs of QSOs separated by arc minutes on the sky show that large numbers of the absorption lines are common to both sight lines. This remarkable result suggests that the Ly α forest absorbers are thin sheets hundreds of kiloparsecs in extent. How such clouds can show constant velocities over such large spatial scales is unknown. Our observations of the gravitationally lensed pair of QSOs PKS 1095+561 A&B each show about 30 Ly α absorption lines, all in common to both spectra. The high signal-to-noise of our observations will allow us to study column density and velocity differences between portions of these clouds separated by only a few kilo-parsecs.

FOS spectropolarimetry provided the first detailed investigation of the peculiar **Seyfert 1 nucleus of MRK 231** in the ultraviolet. These observations provide the first usable UV spectrum of this AGN (IUE spectra have very low S/N). The spectrum portrays a heavily extinguished emission-line spectrum of the active nucleus plus the emergence of a blue continuum shortward of 2400 Å. In addition, absorption features due to He I, Mg I, Mg II, and (surprisingly) Fe II are identified with a well-known optical absorption system blueshifted by 4600 km/s with respect to the emission lines. The blue continuum is attributed to 100,000 hot, young stars surrounding the nucleus. This component dilutes the polarized nuclear light, implying that the intrinsic polarization of the AGN approaches 20% at 2800 Å. The rapid decline in the polarization toward longer wavelengths is best explained by the strongly frequency-dependent scattering cross section of dust grains coupled with modest starlight dilution. The displaced absorption features, UV polarimetry, and optical/IR properties of MRK 231 all point to its classification as a low-ionization ("Mg II") broad absorption line quasar, in which most, if not all, lines of sight to the AGN are heavily obscured by dust and low-ionization gas clouds. MRK 231, therefore, gives us an opportunity to study the astrophysics of a relatively nearby object that is closely related to the high-redshift broad absorption line quasars.

K648 is one of the few Planetary Nebulae (PN) known in the galactic halo. Since K648 belongs to the globular cluster M15, its distance is known better than is usually possible for PN, and the evolution is especially informative. A far-UV spectrum of the central star was obtained with the FOS. This spectrum represents a substantial improvement over the previously existing IUE observations, because of the better S/N and resolution, and because previous flux measurements, through the large IUE aperture, were contaminated by several field objects. After the nebular continuum was subtracted and the extinction removed, the FOS spectrum of the central star was compared with model atmospheres by Kurucz (1993) and by Wesemael (1981, models for high gravity stars). The comparison indicates T_{eff} values lower than most authors found by different methods (see Bianchi *et al.* 1994, 1995 in

preparation). The discrepancy points to a possible problem in the reacquisition during two of the FOS exposures (H130 and H190), that we are investigating, or possibly residual contamination by weak field objects. To complete an evolutionary model of the object, we tried to determine the expansion velocity. High-resolution long-slit spectra were obtained with the Utrecht Echelle Spectrograph (UES) on the 4.2 m William Herschel Telescope at the Observatorio del Roque de los Muchachos (La Palma). The instrumental FWHM was 6.9 ± 0.3 km/s. The seeing was better than 1". In order to calculate the expansion velocity, we took into account that the measured FWHM of the line profile is due to the convolution of thermal, instrumental, turbulent and expansion components. After deconvolution, we find expansion velocities: $2V(\text{exp})[\text{N II}] = 22.6$ km/s $2V(\text{exp})[\text{H}_\alpha] = 33.7$ km/s. The long slit spectra confirm an extension of the nebular shell of about 5.3 arcsec diameter, as seen in the FOC and WFPC-1 images (Bianchi et al. 1995a). The FOS and ground-based data combined yield an expansion age of 7400-11400 yrs, much shorter than the evolutionary age derived from the stellar parameters only (Bianchi et al. 1995a,b).

II. Current Problems

The FOS continues to perform extremely well, and the addition of COSTAR during the First Servicing Mission has returned FOS capabilities to near design specifications, but some planned and approved FOS GTO observations have not yet been scheduled. FOS GTO scheduling was performed at a higher rate during the period of this report than during the previous 6-month period, but it is still not clear that all GTO observations will be scheduled so as to permit analysis by the end of the GTO support period.

III. Plans for the Next Year of Support

The FOS GTO team plans for the next year include a long list of observing programs, of which most were to have been performed by the end of cycle 4. In addition, the team will perform analyses of the observations listed in the first section and complete work on previously obtained data. The HST is now performing up to its original design specifications, which is a testimonial to all those who have worked hard on this project and its maintenance and repair.